VIRGINIA GIS REFERENCE BOOK

General Application Category/Sub Application Name: Public Works/Service Authority – Facilities Mapping

Product, Service
Or Function Name: Water Meter Location Inventory Applications

P/S/F/ Description: An application used by Service Authority/Public Works personnel to locate/identify water meters and may ultimately be used to monitor customer consumption for billing purposes.

Typically, a Service Authority/Public Works Department must know the location of each water meter, so that usage can be tracked and attributed to each customer. Additionally, information may exist that aids in the maintenance and preventative maintenance of the water meters and other facility features. Currently many departments keep meter information in their customer database. The location of the meter should correspond to the address of the customer. In the most sophisticated applications, the physical location of the meter is accurately located via GPS and geocoded to the proper address location.

Product /Service/Function

1.) Spatial Data

Minimum Requirements:
The minimum requirements for spatial data for any application include those data that must be available to the application in order for that application to achieve its intended functional requirements. For a Water Meter Location Inventory Application these data include water meter locations, digital parcel data, geocoded street centerlines, and base data.

1.) Water meter locations: A point layer maintained in a standard CAD or GIS system that defines the location, and optionally other characteristics, of water meters. Attributes may include: a unique feature ID, meter ID, service area name/ID, controlling organization name and contact information, installation date, repair date, map number (from hardcopy source), etc. Related address and property owner/occupant information should also be tracked.

2.) Digital parcels: Polygon layer that contains addressed parcel locations and additional property information such as owner name, occupancy status, business type, number of occupants, etc. can help verify the number and type of users. It can also be used to help identify locations of water meters. This is a set of polygons that has usually been collected for tax mapping purposes and contains extra information about an address and would include zoning information. This is used with a street centerline file to locate an address

3.) Digital road centerline: Vector line file with valid and verified addressing information, preferably through the use of GPS and field verification. This spatial data set would have more accurate feature positioning of addresses/locations by utilizing GPS fieldwork or conventional surveying methods. This is a more spatially accurate road data set that can be used for multiple purposes including locating addresses, and routing service vehicles, and will more accurately represent the location, and relationships between features. Attributes would include road names, address ranges, route numbers, road types, etc.

4.) Digital vector base map layers: Vector layers contain spatial features that are represented by points, lines, areas (polygons), or label points. The purpose of vector base map layers is to present enough background information so that the location and presentation of the water meter location data will be clear to the user. This data should cover the water service area at a minimum, but including potential expansion areas, is recommended.

- Transportation infrastructure layers including airports and landing pad locations, and railroads, will help define the service areas where water meters are located and will enable the identification of the specific locations and directions to each meter. Attributes may include a unique feature ID, feature type (airport), feature name, an address (if applicable), and contact information.
- Hydrographic features such as rivers, lakes, ponds, reservoir, swamps, oceans, bays, etc. should also be presented although the level to which they are collected should be determined by their apparent importance in locating a water meter or associated property. Small farm ponds are not likely needed, while city reservoirs and other major water features are important. Attributes may include: a unique feature ID, feature type (reservoir), feature name, and contact information (if applicable). Hydrographic features, not including feature names, will also be available from the VBMP program for use with the orthophotography. Since this data is being compiled from the imagery, additional conflation should not be needed.
- Jurisdictional boundaries such as city, county, and state boundaries. Attributes may include a unique feature ID, feature type (county boundary), and feature name.

5.) Geo-referenced orthophotography (raster base map): Geo-referenced orthophotography is aerial imagery/photography that is geographically or positionally accurate. It is typically used as an underlying layer or base layer that is presented below all other spatial information. Although geo-referenced orthophotography is not a minimum requirement, it is listed here since the

VBMP 2002 orthophotography product will be an excellent base layer that will help users visualize the locations of structures and/or properties with water meters and view the surrounding characteristics of the area. Using imagery as a base gives a clearer visual representation of an area since it better represents what we actually see and includes all features in an area not just those selected for vector representations. It also helps present basic information on the elevation of objects. It is important to note that using an image base does not preclude the use of vector data. Image bases cannot be used to store textual information for specific features, such as road names, nor can they be used to see all features since some features will be obscured by vegetation, steep terrain, shadows, and other image and ground anomalies.

6.) Metadata: – Metadata is loosely defined as "data about data". In respect to spatial data, metadata is the descriptive information about the data's source(s), scale(s), intended uses, restrictions, development, projection parameters, history, etc. This textual information adds significant value to spatial data since it records and retains descriptive information about a given data layer. If personnel leave, descriptive information about the data remains. If the data is suitable to be used for other purposes (this can prevent redundant data collection) or if there is a problem with the data, the sources and processing steps can be analyzed since they are known. Detailed metadata should be collected, managed, and maintained for each data layer and should be made a requirement of any data created by a contractor. (See Standards/Guidelines Summary).

Before these data layers can be used together, they must be referenced to the same spatial coordinate system; and, then features may need additional positional adjustments in order for the features between layers to appear in the most appropriate place. (See information on Data Conflation Options.)

Optional Requirements:
Optional spatial data requirements include data that are more spatially or descriptively accurate, enable the application to perform additional, related functionality, or enable a more precise view/representation of the area. Some optional data would include the following.

1.) Water and sewer system feature layers. These would include the location of water and sewer service areas, valves, pumping stations, tanks, treatment facilities, intakes, land application areas, and discharge sites. Attributes may include unique feature Ids, feature types, capacities, materials, sizes, ages, service dates, etc. This data can help identify specific users that are affected by a pipe rupture or other service interrupting events by associating service lines with meters and their associated addresses. Likewise, the service lines' usage patterns and system component wear can be tracked by analyzing water usage information. A good example of the types of layers and attributes for this type of data is: Version 2.2; Geographic Data Content Standard for Water Distribution and Sanitary Sewer Systems; State of North Carolina, Geographic Information Coordinating Council; April 1997. More information: www.cgia.state.nc.us/gicc/

2.) Graphical/Spatial reporting of spill incidents or line breaks.

3.) Additional planimetric reference data. This could be information, in the form of hydrology, building footprints, utility system features (gas, electric, telecommunications), and extensive road networks, etc. Some of these features can be collected directly from the VMBP imagery since they can be seen on the imagery.

4.) More spatially accurate digital vector base map data (using GPS and/or surveys) or higher resolution aerial photography or digital orthophotography from multiple sensor types.

5.) Weather modeling information and source water level information for tracking the condition of water supply sources. This may become more important if the long-term drought conditions do not improve.

6.) Automated meter reading equipment that enables actual usage values to be collected based on actual transmitted data instead of estimated usage. This type of system could also help identify suspected leak conditions to help minimize the waste of treated water.

7.) Elevation data can be used to model the terrain's aspect and could be used to help locate structures or properties with water meters, as well as other water system features. The VBMP 2002 orthophotography program will contain a digital terrain model (DTM) that can be used to build elevation perspective models. The applicability of this product to a locality's water meter inventory will have to be evaluated by the locality.

2) Attribute Data

Attribute data is tabular information that stores characteristic of a geographic feature described by numbers, characters, or images, typically stored in a tabular format and linked in a table to feature model by a user-assigned identifier. While not required for all systems, using a relational database management system (RDBMS) to store and manage attributes is the recommended way of enabling efficient attribute storage and database designs. An RDBMS enables the establishment of table-to-table relationships that reduce redundant data storage and enable greater flexibility in database design. The current versions of the main GIS packages rely on some level of a RDBMS to enable their full functionality.

The attributes listed here are in addition to the attributes listed directly with the spatial feature and are stored in related tables.

Minimum Requirements:
The only attributes that need to be tied to the spatial data are a feature identifier. All other attribute data can be stored in related tables. If this is used as an inventory system, than the attributes should include a unique feature ID, feature name, feature type, feature location description, system name, feature description, and pertinent descriptive information on the features' loads, sizes, limits, conditions, etc.

Optional Requirements:

1.) Implementation of a city/county master street address guide (MSAG) that is the main address database for all locality purposes. All other datasets that have an address component should link to this MSAG with a unique identifier. This system would fall under the responsibility of the 911 operations. This would be a major undertaking in most cases; however, it would ensure that all addressing is from the same source and as accurate as possible. MSAG addressing can include the addressing of intersections, cemeteries, airstrips, airports, bridges, parks, structures, and could be used to more accurately locate (by address) water meters.

2.) Implementation of a master water meters database that contains and tracks usage information, address information, owner information, billing information, etc.

3.) Links to hazardous materials databases where available and feasible may help identify potential contamination locations. If a specific section of pipe is being repaired or has been compromised, and line flushing needs to occur, the addresses tied into to the water meter locations can be used for notifying users. Attributes describing material types, recommended remediation methods, location information, contact information, etc.

4.) Links to historical incident tracking databases (burst water lines, contamination from leaking sewage pipes) where available and feasible, that would help identify groups of users who have had repetitive water line or water meter problems. Attributes would include incident identifiers, incident dates, incident descriptions, contamination areas, flow amounts, damage assessments, remediation steps, corrective measures to prevent future incidents, etc.

3) Data Acquisition Options:

Data acquisition efforts should begin by inventorying available data in a systematic manor. Generally, a locality's data will be the most detailed and the data of choice. Start by inventorying the available data within the local departments, starting with the GIS or Engineering departments, and expand to the departments of adjoining localities or regional entities. If no local data exist, state, federal, and private sources can be checked, often using spatial data clearinghouses and other Internet searches. Data that is already in a GIS format, or have a spatial component from which a GIS layer can be generated will be the easiest to prepare but other good quality data should not be disregarded unless the effort of georeferencing the data is not beneficial. Each data will need to be evaluated for its appropriateness for the intended use and its metadata referenced for this purpose.

Water meter locations may exist with a Public Works Department, Service Authority, or with a local utility. Water meter locations are tracked by address and this data typically exists only at the local level. Water meters are too small to be visible on digital orthophotography. Their locations will have to be generated by geocoding address information from a water billing database; by manually digitizing locations from hard copy blueprints, as-built plans, or maintenance records; or by collecting their locations in the field using GPS technology. Some GPS field verification will likely be needed for water meter locations that are generated with any other method.

A digital vector base map data inventory should likewise start with the localities and work up to the small scale sources available from state and federal agencies. The TIGER/Line® data contain a road network with names and address ranges and is free with the exception of media and re-production costs. This data will need to be conflated to the image base since it is not as spacially accurate. To make use of these data, a user must have mapping or Geographic Information System (GIS) software that can import the TIGER/Line® data since the Census Bureau does not provide these data in any vendor-specific format. While this data can be used to approximate the location of a given address, a more detailed method of locating actual meter or structure information is recommended. When trying to locate small features such as water meters, well heads, and manholes, GPS data collection is the most dependable. Transportation features are also available from the USGS and may be available from the Department of Transportation.

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If additional base data layers are being utilized (listed above in optional requirements), this information will need to be collected and/or compiled. In some cases this spatial data will already exist in some manner. If information is on paper maps, then digitizing will need to occur. In most cases, basic framework data (see Standards/Guidelines Summary) will have already been compiled by a third party such as state and federal government entities. In all cases, the spatial base data will need to be verified for accuracy, clipped to reduce the data set to include only the area of interest, and possibly conflated (see below). Examples of third party spatial data may include road networks from VDOT, hydrography from USGS, utilities from local utilities, National Pollutant Discharge Elimination System (NPDES) locations from the EPA, etc.

A digital geo-referenced raster base map will be a very useful component for this application. High-resolution digital orthophotography, or maps generated from these data will provide the most accurate base on which to present the water meter locations and will include many other features visible from the air at a specific altitude. While the water meter locations cannot be collected from the orthophotography, the structures where the are located will be visible and can be used to help identify the property and the routes to get there. This data source will be available through the Virginia Base Mapping Project (VBMP) initiated by the Virginia Geographic Information Network (VGIN).

Hydrographic features, not including feature names, will also be available from the VBMP program for use with the orthophotography. Since this data is being compiled from the imagery, additional conflation should not be needed. Hydrographic line data and some name data are available from the USGS from the National Hydrography Dataset (NHD). Hydrographic names are available from the USGS in the form of the Geographic Names Information System (GNIS) and their locations can be conflated to overlay with the orthophotography.

Digital terrain model (DTM) data from which 3-dimensional perspectives can be created will be a by-product of the VBMP program.

If additional addressing information is needed, an Emergency Management, Land Records, or Planning department may have the required information.

4. Data Conflation Options:

Conflation is the method whereby a geographic feature is adjusted to fit a more accurate base map. Conflation will help to ensure that all locality data are positionally in the same space in relation to each other on earth. With the use of an accurate digital image, the position of associated vector data is conflated to overlay the position of the same features on the image base. Typically the best base map for conflation purposes is a current, high-resolution digital orthophotography product. It is paramount that the orthophotography is as accurate as possible since any error in the imagery will also be reflected in any feature that is located using that imagery. Feature layers that were created by on-screen digitizing directly from the orthophotography should not need conflation if the orthophotography is being used as the base.

Water meter locations cannot be directly located on the orthophotography but other features associated with them, such as structures, are visible. Even if the water meter locations are generated from an address database, or are digitized from hardcopy products, they will likely need to be conflated to the imagery if the source they were generated from had not been conflated.

The conflation process can occur in a variety of ways, with the least sophisticated being a “best-fit” methodology.

The best-fit method is a visual inspection or comparison of a geographic feature’s current position to where it is or should be located on the more accurate base map. This method would either entail:

1.) moving the entire road lines layer across the imagery (like sliding one sheet of paper over another) until the greatest number of roads aligned as closely as possible with their counterparts on the imagery; or,
2.) moving individual road lines, or sets of road lines, so that they align as closely as possible with their corresponding road/s on the imagery.

These methods may be the best solutions in many cases since it will take less time than other options and will be the fastest to implement. Additionally, the availability of the VBMP orthophotography will provide a good base map to which to “fit” features. This method uses visual judgement to determine the best fit of the features.

Another conflation option includes rubber sheeting: a method using control points or existing boundaries to establish the new geographic position of a feature. Using roads as an example, control points at road intersections that can be clearly identified on both the digital imagery and on the road vectors are used to “stretch and shrink” the vector roads so that their positions correspond at the control points. The more control points that are used, the more precisely the data will fit. This method uses two sets of control points and a GIS algorithm to adjust the vector feature locations.

Finally, the most accurate method of conflating data includes the use of Global Positioning Satellite technology (GPS), or traditional survey instruments to accurately locate each desired object’s physical location. While this is very accurate in most cases, the existence of an orthophotography base map product may be the best source for conflation because when viewing data/maps with different layers present, it is desirable to have the framework or vector data “fit” over the orthophotography. If a wide base of accurate GPS spatial data is already present then conflating the orthophotography may be satisfactory. This method uses direct field measurements, the most spatially accurate data as control points, and an GIS algorithm to adjust the imagery.

Any data not collected directly from the image base will likely need some level of conflation if it is to be overlaid effectively with the orthophotography.

5. GUI / Programming Options

A graphical user interface (GUI) enables a user to perform desired tasks by using a mouse to choose from a "dashboard" of options presented on the display screen. These are in the form of pictorial buttons (icons) and lists. Some GUI tools are dynamic and the user must manipulate a graphical object on the screen to invoke a function. For example: moving a slider bar to set a parameter value (e.g., setting the scale of a map). The GUI is the interface used to interact with the data and perform analysis functions.

A Water Meter Location Inventory Application should have the ability to show the point locations of the meters, other water system features, the reference information used to locate the features, other related features or incident locations that relate to the system, and report the descriptive attribute information to the user. For inventory management, the ability to search for specific system components or input maintenance or repair requests could also be available. Links to ordering/inventory information with images, technical descriptions, and availability information on system components (replacement pipes, meters, meter covers, etc.) can also be part of the interface. This type of application is generally used by the managing agency and could optionally be made available to field personnel. Some components of the interface may include:

1.) Input text boxes that enable searches against a database of water meter parameters can be used for both feature identification and for data input. There should be a one-to-one correspondence between the search components and the attributes in the database so that additional time does not have to be spent parsing the data before searching.
2.) A summary of the input information should be easily visible from the map view port.
3.) A map view port large enough for users to easily ascertain location information and object information.
4.) If the system has additional layers (other than water meters) available in the application such as utilities, hydrology, building footprints etc., then the system should give the user the ability to turn certain layers on and off for reference purposes. This usually appears as a scrolling list of layer names and check boxes.
5.) The application interface should also give the user the ability to view current and historical information on line repairs, water contaminations, reported service problems, maintenance records, etc., for a particular location and give the user the ability to run additional queries.

GIS software can be modified utilizing a variety of programming languages or scripting languages that may vary depending upon the system architecture. This will enable the customization of the application interface and functions to meet non-standard requirements. Languages such as Microsoft Visual Basic are commonly used to invoke macros and customized functions such as GIS queries.

Commonly used languages include: Visual Basic, C++, Java, HTML, ASP, ColdFusion, JSP, PERL, PHP and CGI.

For data that can be modeled as a "system" of interconnecting parts, certain GIS applications enable the development of "smart feature" models (called a GEO Database by ESRI). These allow feature characteristics to be defined within a database, enabling system constraints and functionality to be stored with the features. This reduces the amount of programming in the interface. For example: A pipe inventory stored in this type of system would present the pipes and connectors of the system graphically. If a user tried to place an inappropriate fitting between two pipes (a fitting that connects a 6 inch pipe with an 8 inch pipe, would not be allowed between two 8 inch pipes) the system would flag the error and warn the user. This also helps when the system is being used for system maintenance.

6. Internet Functionality and Options

Internet functionality generally refers to public access to a system through the use of the Internet, or a public portal to a system that is password protected so that while the public can view the portal over the Internet, only authorized uses can gain direct access and use the application. These access types are generally enabled through a standard web browser. This is different than Intranet access, where access is limited to a specific computer network, usually one agency or group of agencies, and allows no public access.

A Water Meter Inventory application is not usually publicly accessible and therefore not available to the public through the Internet. For access by field personnel, or other agencies, presenting this information over the Internet may be advantageous. If public viewing of the system's feature data, usage data, or historical event data is desired, presenting it in a standard map window with related base data can be achieved fairly easily. These applications can take advantage of web browser interfaces, Internet transfer protocols and the flexibility of the Internet programming languages. Since web browser interfaces are so widely recognized and understood and since the programming languages are robust and enable the customization of the standard application interfaces, they are used in creating these types of applications. The advantage of Internet protocol interfaces is that data transfer is very fast.

Standard Internet mapping functionality would include basic GIS functions available in a thin client GIS application, such as ESRI's ArcExplorer (i.e. Zoom In, Zoom Out, Pan, Identify, Query, Thematic Mapping … etc.). Additional functionality may include appropriate hyperlinks to critical and related information on the Internet related to certain queries or operations within the application. An Internet application allows the organization to share its spatial and tabular information to all authorized users via a familiar Internet Browser interface. This eliminates multiple software license fees. Additionally, the Map Server (Web Server) is the only GIS hardware/software component that would be managed by the localities Information Technology Department.

7. Minimum Technical Requirements

The basic technical requirements needed to set up the GIS component of a Water Meter Inventory system are listed below.

1.) A Basic working knowledge of a leading GIS software, and Internet Browser are required.
2.) A Pentium III or greater CPU, with a minimum of 128MB Ram, 16MB Video Card, is required. A high speed Internet connection is recommended for GIS Internet application deployment and analysis.
3.) Most leading GIS software is customizable using MS Visual Basic or another common language. It is suggested that the developer have a working knowledge of (at least) Visual Basic before attempting GUI development.
4.) T1 or better connections to the Internet for access by field personnel.
5.) Server should be RAID level 5 with two stage back-up (mirrored systems as well as tape back-up) to minimize data loss and to enable quick data recovery.

Optimum Technical Requirements:
For a fully integrated mapping and robust Water Meter Inventory system, the options are near limitless. Below are some of the components that could be implemented to utilize the full benefit of a spatial/GIS based application.

1.) GPS units for all field data collection.
2.) A robust RDBMS networked to other departments as a central repository for all locality spatial data.
3.) An integrated work order system capable of tracking system conditions and managing work orders.
4.) Implementation of a 2-stage back-up and recovery system for rapid recovery of system failures.

In the case where a local government employs a highly capable Information Technology Department, other languages may be considered, such as JSP, Java, Visual Basic, ASP, and Cold Fusion. In most cases, these languages are related to Internet application development. A web developer with three years of experience should be able to customize and/or develop a unique Internet Map Server application.

8. Administrative / Management Requirements

A Service Authority or Public Works Department is concerned with analyzing information within their entire service area. The water meter locations, as well as the other related system features contained in the area, will require upkeep. If any water meter information is modified or meters added or removed from service, it must be reflected in the application source data. Similarly, if a joined ancillary database table is updated, the application data must reflect the change. The maintenance of a general facility base map (roads and other framework data), may be the responsibility of the Service Authority or Public Works Department. However, if the base map was obtained from a third party, such as the County Planner, an update may be available upon request.

A manager or administrator implementing a project of this nature will need a strong project management skill set due to the variety of the components that will be involved and have (or develop) a thorough understanding of water systems and the role of water meters in that system. There are seven (7) main areas where administration and management requirements will need to be concentrated:

1.) Fiscal – Pre-planning and research on how other localities implemented similar systems is recommended. A manager with good fiscal, budgeting and money management skills will be helpful.
2.) Personnel - This type of implementation should require limited staff resources but some technical expertise in GIS and application development will be required. If contractors are hired for any part of the implementation or maintenance, the manager would oversee their performance as well. Good personnel management skills will be required.
3.) Technology – A manager with a good understanding of GIS is recommended, but this type of application does not require extensive technical knowledge. The manager will need experience in selecting technical human resources.
4.) Political/Stakeholder Involvement – The ability to work with a limited number of external stakeholders may be needed. In this case, the Service Authority or Public Works Department may want connectivity to the planning data so that new installations can be anticipated, or to the water systems data so that repair notices can be sent to the affected customers.
5.) Training – Training will likely be limited to the technical personnel running and maintaining the system and potentially the staff of other agencies.
6.) Operational – Day-to-day operations will be limited unless the locality is large and requires extensive daily maintenance. Scheduling may be required.
7.) Maintenance – Once the system is in place, on-going maintenance will need to occur. Before the system ever reaches this stage, the manager should be able to develop a plan identifying what resources are needed, what resources are expected to be available, and how maintenance will be performed. This will help guide the system requirements, and help ensure that and initial implementation is not undermined by the inability to support it over time.

In general, management concerns will involve technical support, system maintenance, and human resource management of technical staff. Technical and administrative issues become more critical and consuming when developing and/or hosting an application in-house. General expertise in GIS is suggested if outsourcing application development and hosting. In-house application development and hosting will require a GIS specialist, an advanced web programmer, and technical material resources (hardware/software).

9. Cost – Cost/Benefit

The specific costs and range of costs for this type of application will very greatly depending on the locality's needs, expectations, existing functionality and physical resources. The estimates below are approximations based on previously performed work.

Application Development: The cost of developing a water meter inventory application (in-house) costs approximately $2 per parcel (locating a water meter for each applicable parcel) and typically can be performed for under $50,000.

Most of this cost is attributed to the digitization/GPS verification and attribution of each water meter point. Programming the application, which includes a GUI that can post custom queries, accounts for less than 50% of the project costs. This cost/benefit is highly favorable. Essentially all the data is freely obtained or developed in-house.

Program Development: Developing a water meter location inventory program from scratch, that includes: application development, data production of water meter locations, pipe lines and service area features, data conflation, hiring of staff, contract development/negotiations, multi-agency networking, database creation, field verification of data, all hardware and software, training, etc., could ake a couple years and run into the hundreds of thousands of dollars. Additional maintenance costs would also need to be projected.

A water meter location inventory program, that includes application development, can help save money by:

- enabling spatial analysis and understanding of where water meters exist;
- enabling the implementation of a system component maintenance program that can help avoid costly repairs by tracking the condition of the components;
- enabling more efficient routing of service or meter reading personnel;
- enabling more efficient collection, management, and monitoring of water billing and usage statistics;
- enabling the tracking of needed future repairs for budget projections; and,
- enabling other programs to use this data with their application in order to see how their data interact and relate to the water meter data and related features and usage statistics (such as the Planning Department when determining development impacts).

10. Standards / Guidelines Summary

A good example of a state standard for water and sewer data is: "Version 2.2; Geographic Data Content Standard for Water Distribution and Sanitary Sewer Systems"; State of North Carolina, Geographic Information Coordinating Council; April 1997. More information: www.cgia.state.nc.us/gicc/

Where applicable, industry standards for computer formats (including ANSI), Internet communications protocols (like TCP/IP), and other relevant technology standards should be used.

The Information Technology Resource Management Guideline, "Model Virginia Map Accuracy Standards", COV ITRM Guideline 92-1, 3/20/92; is a State of Virginia Standard defining a common recognized standard to guide the collection of data for all map scales; a method for verifying and interpreting the data collected and map products produced; and a method of labeling data and map products. For more information: www.vgin.state.va.us/documents/guidelines-standards/guidelines-standards.html

The Federal Geographic Data Committee (FGDC), with consensus from local, state, federal, and private reviewers, created and maintain the "Content Standards for Digital Geospatial Metadata" (soon to become an international standard) to enable consistent and comprehensive recording of the content, quality, condition and other characteristics of spatial data. For more information: www.fgdc.gov

Seven (7) base map layers that have been recognized by the Federal Geographic Data Committee (FGDC), with consensus from local, state, federal, and private reviewers, are termed "Framework" layers. These layers are generally considered the main layers that most mapping organizations need to best enable and support their functions. They are: geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information. The FGDC has developed procedures, technology and guidelines (including basic attribute requirements) that provide for the integration, sharing, and use of these data and have also identified institutional relationships and business practices that encourage the maintenance and use of these data. For more information: www.fgdc.gov/framework

11. Startup Procedures/Steps

The need for the development of this type of application usually stems from an identified need for the service. Once this is recognized, a cost/benefit analysis will help determine if the resources and the benefits further warrant the development. If so, than the system itself can be addressed.

Regardless of whether the work will be performed in-house, or fully/partially contracted, a three-phase approach works well.

1.) Needs Analysis - The first step is to do a "**needs analysis**" on the current system, or planned system. This will clearly identify and record the goals and resource needs of the project and will later be used to define the project steps. A needs analysis should include:
    - the overall goals and expectations of the system;
    - an inventory of current and expected resources;
    - identification of components that need to be developed/added;
    - what types of products/documentation are expected;
    - what cooperative efforts and stakeholders will be involved;
    - what time parameters are involved;
    - what standards need to be used and what thresholds monitored; and,
    - how will the system be managed over time.

    The needs analysis does not focus on implementation strategies, only on the what the system needs to do and what resources will be need to be involved.
2.) With the needs analysis to guide and set goals, a **"systems design"** that meets those needs can be developed. This focuses on how the system gets built and determines:
    - what physical resources (specific hardware, software, etc.) will be used;
    - who will manage what components of the system;
    - where will the system reside;
    - who will build/manage/maintain each part of the system;
    - how will the system be used, step-by-step, to achieve the goals; and,
    - what type of specific, on-going support will be established.

    This focuses on the specifics of the system (the type, name, and size of computer), the human resources to manage it, and the way it will work and be maintained. The particulars of any given aspect may evolve as the system design is developed and specific questions or hurdles are discovered.
3.) Now that an actual design has been determined, an **"implementation plan"** describing how the system will be implemented needs to be developed. This begins the physical implementation of the system. The implementation plan defines the:
    - order of the implementation steps, (putting data in the system relies on the existence of the data);
    - time, money (costs), personnel resources, and stakeholder dependencies (this must occur in order for that to occur);
    - deliverables, formats, and documents by tasked entity (who does what, when and how);
    - implementation phases and task timelines (this task should take this long);
    - roles of the stakeholders, their expected tasks and commitments; and,

- future implementation/maintenance tasks and how they get accomplished.

If the work is be contracted, than these documents should outline the role(s) of the contractor(s) as well. This is the step-by-step guide to "making the system".

Some specific project steps may include:

1.) Researching standards, available data, other implementations, and possible outside funding sources.
2.) Inventory existing/expected resources (hardware, software, staff, money, etc).
3.) Develop an application outline/blueprint, focusing on the application's purpose, interface design, functionality, querying capabilities, and "look and feel". Stakeholders should be involved in this step.
4.) The attribute data will need to be obtained from the various sources mentioned earlier and normalized and related where necessary. Spatial data will need to be compiled from a variety of sources, or, if it is not available, then it will need to be collected and developed.
5.) Determine the entity/entities that will be performing data development functions, application development functions and application hosting functions and create a project plan with budget numbers.
6.) Develop an implementation plan that includes timelines and milestones.
7.) Create a data development/transformation plan that includes metadata definitions, a database schema, and data dictionaries with relational information.
8.) Readdress your project plan, timelines and budgets as a final initial process before committing resources.

It is recommended that the database application functions be addressed and implemented before the mapping functions.

12. Estimated Time Line and/or Implementation (stand alone) Schedule

Time line and implementation schedules will be determined on an individual entity/locality basis since there is a very wide variety of implementation approaches based on the current status of data and other resources of a particular locality.

The actual duration is defined by the availability and condition of water meter information. Typically a basic application can be developed in a little as three (3) months, to as much as five (5) months. Typically, this type of application can be developed in about 750 man-hours.

If the locality is planning a comprehensive overhaul or starting from the ground level, the data collection process, system implementation and integration may take a couple of years. Hiring staff, manually compiling data and digitizing it, researching information from long-time Utility Department or other staff, implementing a system, programming the application, etc., will all contribute to the time estimates. These types of jobs can typically be performed in less time, and possibly less overall money, if they are contracted to qualified firms since these firms have dedicated and knowledgeable staff experienced and ready to go.

13. Best Practice Examples in Virginia

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